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Holonomic Robots – Holonomic Movements

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Index

Introduction

Description

Results

Conclusion

References

Introduction

- **This presentation focuses on movements of Omnidirectional Robots (holonomic).**
- **It’s part of a work beeing done under the undergoing *SocRob* (Soccer Robots) project at ISR, which deals with soccer player robots.**

Introduction: Motivation

Motivation for robot movements research:

- **The type of unrestricted kind of movement provided by omnidirectional robots and it’s aplications on soccer robots.**
- **The behaviours that can emerge from these movements can create advantage on the field.**

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Introduction: Objectives

It's this work objective to:

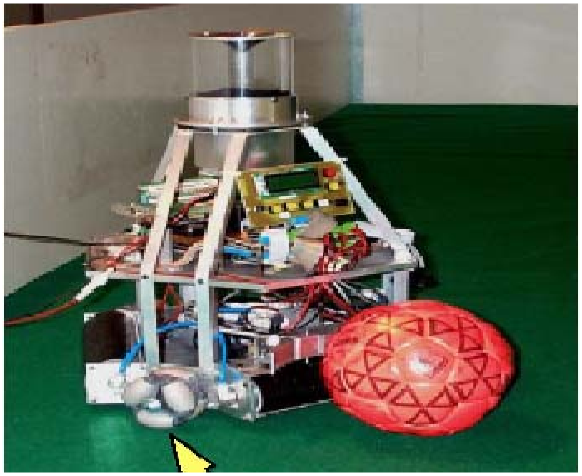
- **Study omnidirectional robot cinematics**
- **Study and specify basic and complex movements**
- **Discuss possible emerging behaviours**

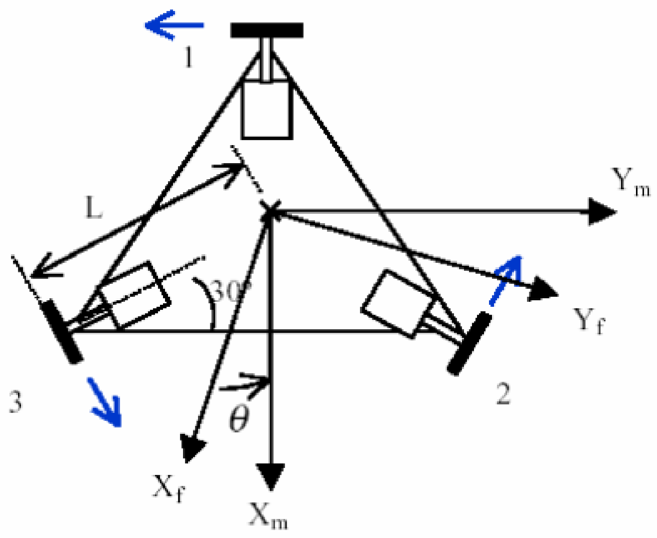
Description

We shall get an understanding of these topics:

- **Physical structure**
- **Direct Kinematics**
- **Inverse Kinematics**
- **Basic Movements**
- **Complex movements**

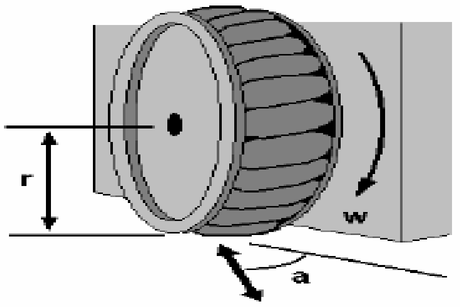
Description: Physical Structure





This specific physical structure corresponds to the future soccer player robots.

A triangular structure with 3 Swedish wheels is used as shown in the pictures.



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Description: Direct Kinematics

The direct kinematics are derived from the physical structure of the robot.

The first relation states the robot velocity w.r.t the robot frame in terms of the wheels angular movement.

r and l are physical values from the robot structure.

$$\begin{bmatrix} V_x \\ V_y \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & -\frac{1}{\sqrt{3}}r & \frac{1}{\sqrt{3}}r \\ -\frac{2}{3}r & \frac{1}{3}r & \frac{1}{3}r \\ \frac{r}{3l} & \frac{r}{3l} & \frac{r}{3l} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}$$

$$V_x = \frac{1}{\sqrt{3}} r(-w_2 + w_3)$$

$$V_y = \frac{1}{3} r(-2w_1 + w_2 + w_3)$$

$$\dot{\theta} = \frac{r}{3l}(w_1 + w_2 + w_3)$$

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Description: Inverse Kinematics

The inverse kinematics is derived from the direct kinematics of the robot.

The equation states the wheel angular velocities in terms of the robot velocity w.r.t the robot frame.

r and l are physical values from the robot structure.

$$\begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} = \begin{bmatrix} 0 & -\frac{1}{r} & \frac{l}{r} \\ -\frac{\sqrt{3}}{2r} & \frac{1}{2r} & \frac{l}{r} \\ \frac{\sqrt{3}}{2r} & \frac{1}{2r} & \frac{l}{r} \end{bmatrix} \begin{bmatrix} V_x \\ V_y \\ \dot{\theta} \end{bmatrix}$$

$$w_1 = \frac{1}{r}(-V_y + l\dot{\theta})$$

$$w_2 = \frac{1}{r}(-\frac{\sqrt{3}}{2}V_x + \frac{1}{2}V_y + l\dot{\theta})$$

$$w_3 = \frac{1}{r}(\frac{\sqrt{3}}{2}V_x + \frac{1}{2}V_y + l\dot{\theta})$$

Description: Basic Movements

Basic movements are those for which is used static wheel angular velocities.

There is a set of basic movements:

- Linear movement
- Circular movement

These are the only kind of movements that can be done wuth static wheel angular velocities.

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Basic Movements:Linear Movement

Analising the direct kinematics equations we have:

- **For X movement only, w.r.t the robot frame:**
  - **w1 = 0 and w2 = - w3;**
- **For Y movement only, w.r.t the robot frame:**
  - **w2 = w3 and w2 + w3 = - w1;**
- **For X and Y simultaneous movement w.r.t the robot frame:**
  - **w1 + w2 + w3 = 0;**

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Basic Movements:Circular Movement

A circular movement has:

- **Tangencial velocity**
- **Angular velocity**

Analising the direct kinematics equations we have:

- **Any velocity especified for the robot in terms of Vx and Vy will be the tangencial velocity.**
- **The angular velocity will be third component of the robot velocity.**

The radius is given by the following relation

$$r = \frac{v}{\omega}$$

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Description: Complex Movements

Complex movements are those for which is used dynamic angular wheel velocities.

These can be:

- Path following with a static orientation
- Path following facing a dynamic orientation

All movements can be specified with these two cases.

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Description:Complex Movements

To implement there movements there is the need make:

- **Interpolation of the path between postures**
- **Calculate the robot velocity which takes him from one posture to the next**

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Description: Behaviours

From these kind of movements can arise interesting new robot behaviours:

- **Stopping the ball without any mecanical device (under certain conditions)**
- **Protecting the ball from an opponent**
- **Golie follow ball behaviour**
- **Moving facing a team member (useful for passing)**
- **Always facing the ball**

These are only a few, and more research should be done.

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Results

- We'll show a simulator that tests the basic kind of movements.
- Another simulator was developed to test more complex movements, e.g. Circular movements with a given angular velocity w.r.t the robot.
- No simulation has been done for other movements yet.

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Conclusion

The omnidirectional robot properties are useful for the domain in which they are to be applied.

The robot movement control can’t be done with basic movements.

From the omnidirectionality property of the robots new behaviours can emerge.

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- **Xiao, Jizhong, “Introduction to robotics”, City College of New York, 2002;**